Estimate of Sooty Tern *Onychoprion fuscatus* population size following cat eradication on Ascension Island, central Atlantic

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Estimation de la population de Sternes fuligineuses *Onychoprion fuscatus* suivant l'éradication des chats sur l'île de l'Ascension, Atlantique centrale. Les chats d'origine domestique, qui avaient tué de nombreuses Sternes fuligineuses *Onychoprion fuscatus* sur l'île de l'Ascension, ont été éradiqués en 2002–2004. Les effets bénéfiques de cette éradication sur la taille de la population nicheuse devaient cependant encore être prouvés. Des données ont été rassemblées entre 1990 et 2009, et il est estimé qu'en 2010 la population comprenait 414,000 oiseaux. La durée de la saison de nidification était de193 jours, ce qui constitue une augmentation de 30 jours (ou 18%) par rapport à la durée moyenne des saisons de nidification précédentes. Bien qu'il y ait une augmentation du nombre des oiseaux nicheurs, celle-ci n'est pas statistiquement significative. Des inventaires supplémentaires sont nécessaires pour étudier l'évolution de la population. Il y a des rapports anecdotiques selon lesquels de nombreux jeunes ont été élevés avec succès en 2010.

Summary. Feral cats, which had been depredating the population of Sooty Terns *Onychoprion fuscatus* on Ascension Island, were eradicated between 2002 and 2004. However, beneficial effects of this eradication with respect to the size of the breeding population have yet to be demonstrated. Census data have been gathered between 1990 and 2009, and we estimate that in 2010 the population comprised 414,000 birds. The duration of the breeding season was 193 days which is an increase of 30 days (or 18%) on the mean length of previous breeding seasons. There is an apparent increase in abundance of breeding birds but this was not statistically significant. Further censuses are imperative to characterise the population trend. There were anecdotal reports of numerous chicks fledging in 2010.

Isolated seabird populations are often slow to recover when threats to their existence are removed and repeat population censuses are essential to evaluate the effectiveness of remedial conservation action (Mitchell *et al.* 2004). Removing predators can benefit seabirds by reducing mortality (Nogales *et al.* 2004), permitting recolonisation (Ratcliffe *et al.* 2009) and population recovery (Donlan *et al.* 2007). Because large numbers of fledglings may be an important attribute in population recovery (Jenouvrier *et al.* 2009), it is essential to maintain records of population size and relative productivity over the years of a population's recovery.

The United Kingdom Overseas Territory (UKOT) of Ascension in the central Atlantic Ocean (07°57'S 14°24'W) is a geographically isolated island of 9,700 ha that lies approximately 2,000 km from the African coast, 2,300 km from South America and 1,400 km from the nearest island, St. Helena (Fig. 1). The introduction of feral cats *Felis silvestris* in 1815 resulted in the extirpation of many avian species from the main island (Ashmole *et al.* 1994). Only Sooty Terns *Onychoprion fuscatus* (Fig. 2) have managed to co-exist with cats on the main island but even their population has decreased in size (Ashmole *et al.* 1994). The eradication of alien predators such as feral cats has resulted in the recovery of native populations (Nogales *et al.* 2004) but the removal of such top predators can have unforeseen consequences for seabird populations (e.g. Stonehouse 2002). Therefore, the outcome of any intervention requires careful monitoring.

On Ascension cats were eradicated between 2002 and 2004. As a result, relict seabird populations have returned from offshore stacks to breed on the main island of Ascension (Ratcliffe *et al.* 2009). The breeding range, numbers of nests and their success in these small populations of boobies (Sulidae) and tropicbirds (Phaethontidae) are regularly monitored and show an increase (e.g., Ratcliffe *et al.* 2009, Hughes *et al.* 2011).

The outcome of cat eradication for Sooty Terns is less easily evaluated as the population is large (Hughes *et al.* 2008) and young adults

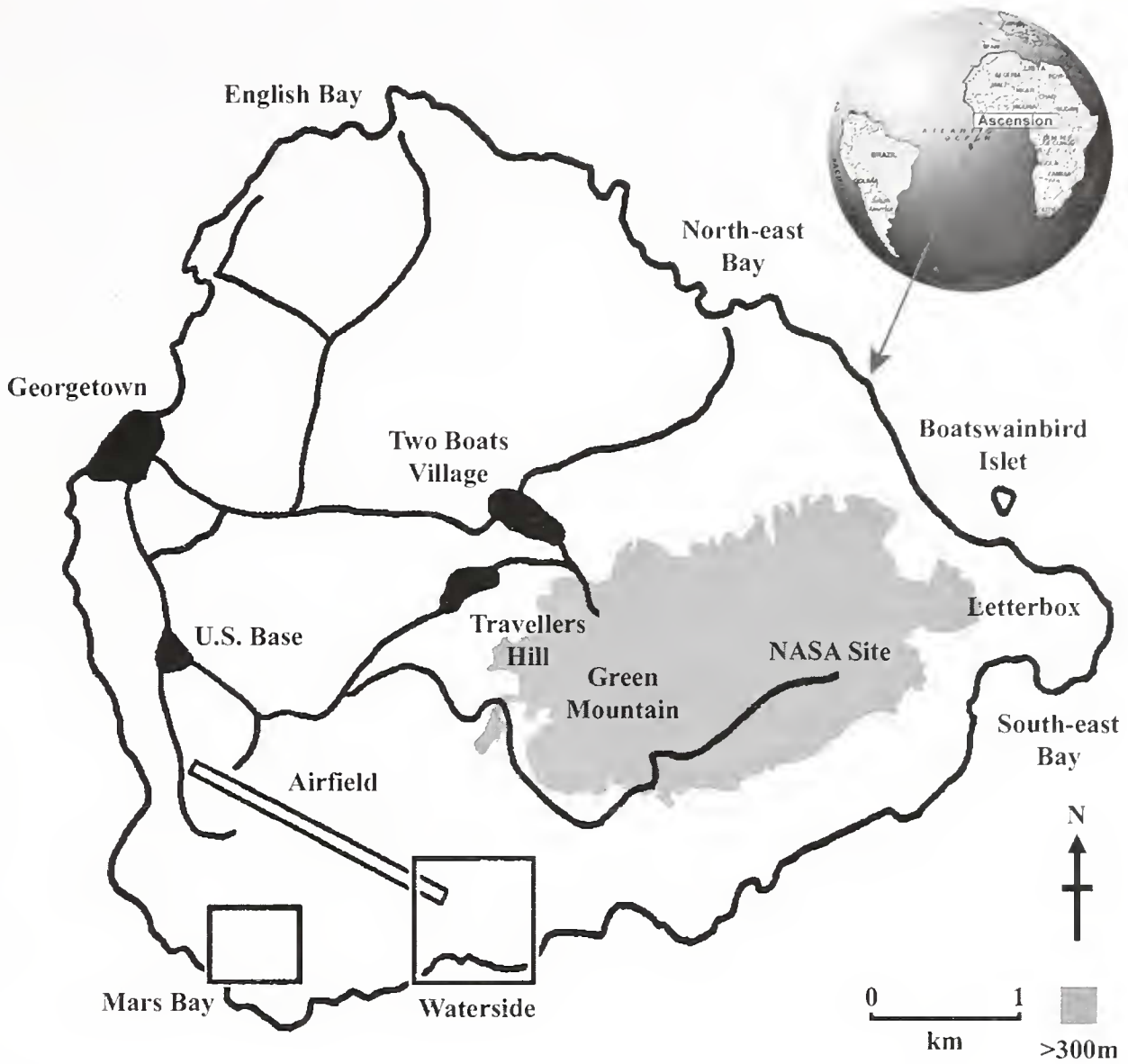

Figure 1. The location of the United Kingdom Overseas Territory (UKOT) of Ascension Island in the central Atlantic relative to the African and South American continents, and a map of the island showing the locations of the main colonies of Sooty Terns *Onychoprion fuscatus*.

Situation du Territoire d'Outre-mer du Royaume-Uni de l'île de l'Ascension dans l'Atlantique central par rapport aux continents africain et sud-américain, et carte de l'île indiquant la localisation des colonies principales de Sternes fuligineuses *Onychoprion fuscatus*.

defer breeding for five or more years (Schreiber *et al.* 2002). On Ascension Sooty Terns breed sub-annually (every 9.6 months) (Chapin 1954) and are absent from the island for three months between breeding seasons (Hughes *et al.* 2008). These factors must be considered when predicting the date of the peak of the breeding season, to ensure that field work coincides with the population maximum of each breeding cycle. The number of adults that returned to breed in 1990–2007 has varied between 150,000 and 420,000 birds (Hughes *et al.* 2008). Seasons with high egg productivity are characterised by above-average numbers of birds returning to breed and a long breeding season. Sooty Terns have the ability to replace eggs lost early in the season (Feare 1976) and on Ascension 13% of egg losses are replaced (Ashmole 1963). Estimates of breeding density and colony area are used to census large colonies of ground-nesting seabirds (Bibby *et al.* 2000) and were used in the first census of Sooty Terns on Ascension in 1990 and during subsequent breeding seasons. In the decade prior to cat eradication the population appeared stable with a mean population size of 368,000 ± 82,000 birds (± 95% CI, $n = 4$) (Ratcliffe *et al.* 1999).

Sooty Terns are not unusual among seabirds in having life histories characterised by longevity, low fecundity and deferred breeding (Schreiber & Burger 2002). To obtain a reliable estimate of population trends of adult Sooty Terns on Ascension, multi-season censuses of breeding adults are required. To achieve this, censuses of the species' colonies were completed each breeding season between 2000 and 2009 by teams from the Army Ornithological Society (AOS), but they were unable to undertake a census in 2010. However, by pooling information from visiting ornithologists, the AOS and the Ascension Island Government (AIG), sufficient data were available

to estimate the population size and bridge the potential gap in the AOS long-term dataset. Here, we report on the success of the Sooty Tern breeding season between May and September 2010.

Methods

The breeding population in 2010 was estimated using similar census techniques to those employed between 1990 and 2009. However, the 2010 census was not planned and the survey dates may have missed the peak in breeding activity. Sooty Terns breed in two colonies, at Mars Bay and Waterside (Fig. 1). To census the colonies the estimated mean nest density was applied to the estimated area of the breeding colony (Bibby *et al.* 2000). The perimeter of the Sooty Tern colony was surveyed twice during the 2010 breeding season. A Global Positioning System (GPS) survey of the colony at Mars Bay was completed on 21 May 2010 and GPS surveys at both Mars Bay and Waterside were made on 25 September 2010. To estimate the area occupied by nesting birds the survey data were inputted to an ESRI's ArcMap 9.2 Geographical Information System (GIS). Population size was estimated by multiplying the area of the colony in 2010 by the mean nest density obtained from previous breeding seasons. Between 2000 and 2009 mean nest density was obtained from surveys of 3,587 quadrats in the Sooty Tern colonies at Mars Bay and Waterside. Dates of egg-laying initiation and departure, and duration of the breeding season were obtained from AOS field records and regular visits by Conservation Office staff to the tern colonies. Further details of the survey methods are reported in Hughes *et al.* (2008). In 2010 AIG weekly reports also provided anecdotal evidence of breeding success.

Results

The duration of the 2010 breeding season was 193 days, with the first egg laid on 14 April (AIG 2010a) and the last juveniles departing on 24 October (AIG 2010c).

The area of the Mars Bay colony on 21 May (37 days after the first-egg date) was 7.57 ha and on 25 September (164 days after the first-

Figure 2. The Sooty Tern *Onychroprion fuscatus* colony at Waterside, Ascension Island (B. J. Hughes)
Colonie de Sternes fuligineuses *Onychroprion fuscatus* à Waterside, île de l'Ascension (B. J. Hughes)

egg date) the area was 12.38 ha. The egg / nest density at Mars Bay during the breeding seasons between November 2000 and October 2009 varied between 2.02 and 0.96 eggs / nests m^{-2} and the mean was 1.436 eggs / nests m^{-2} (se = 0.107, *n* = 10) (BJH unpubl. data). The numbers breeding on 21 May and 25 September were 218,000 ± 36,000 (± 95% CI) and 356,000 ± 60,000 birds, respectively.

The area of the Waterside colony on 25 September was 3.51 ha while the egg / nest density at Waterside during the breeding seasons between November 2000 and October 2009 varied between 2.23 and 1.41 eggs / nests m^{-2} and the mean was 1.817 eggs / nests m^{-2} (se = 0.081, *n* = 10) (BJH unpubl. data). Therefore, the number breeding was estimated to be 127,600 ± 13,000 birds.

Taken together, the best estimate of the size of the breeding population of Sooty Terns on Ascension in 2010 was 414,000 ± 50,000 birds.

Discussion

Monitoring is essential for evaluating the outcome of conservation action. Clear evidence of the recovery of the UK population of Cirl Bunting *Emberiza cirlus* following the provision of grass margins was obtained via monitoring (Peach *et al.* 2001). However, despite possessing 15 years of monitoring data, Girardet *et al.* (2001) were unable to distinguish between the possible effect of cat predation and natural variation in bird numbers, and recommended collecting a longer dataset. Long-lived species require long-term monitoring and a continuous sequence of census data is needed to avoid missing significant population fluctuations. In 2010 the Sooty Tern breeding population was estimated to be 414,000 ± 50,000 birds, representing an increase in population size from the mean of censuses in 2008–09 when it numbered 339,000 ± 103,000 birds (*n* = 3) (BJH unpubl. data). The Sooty Tern population in 2010 was greater than estimates from post-cat

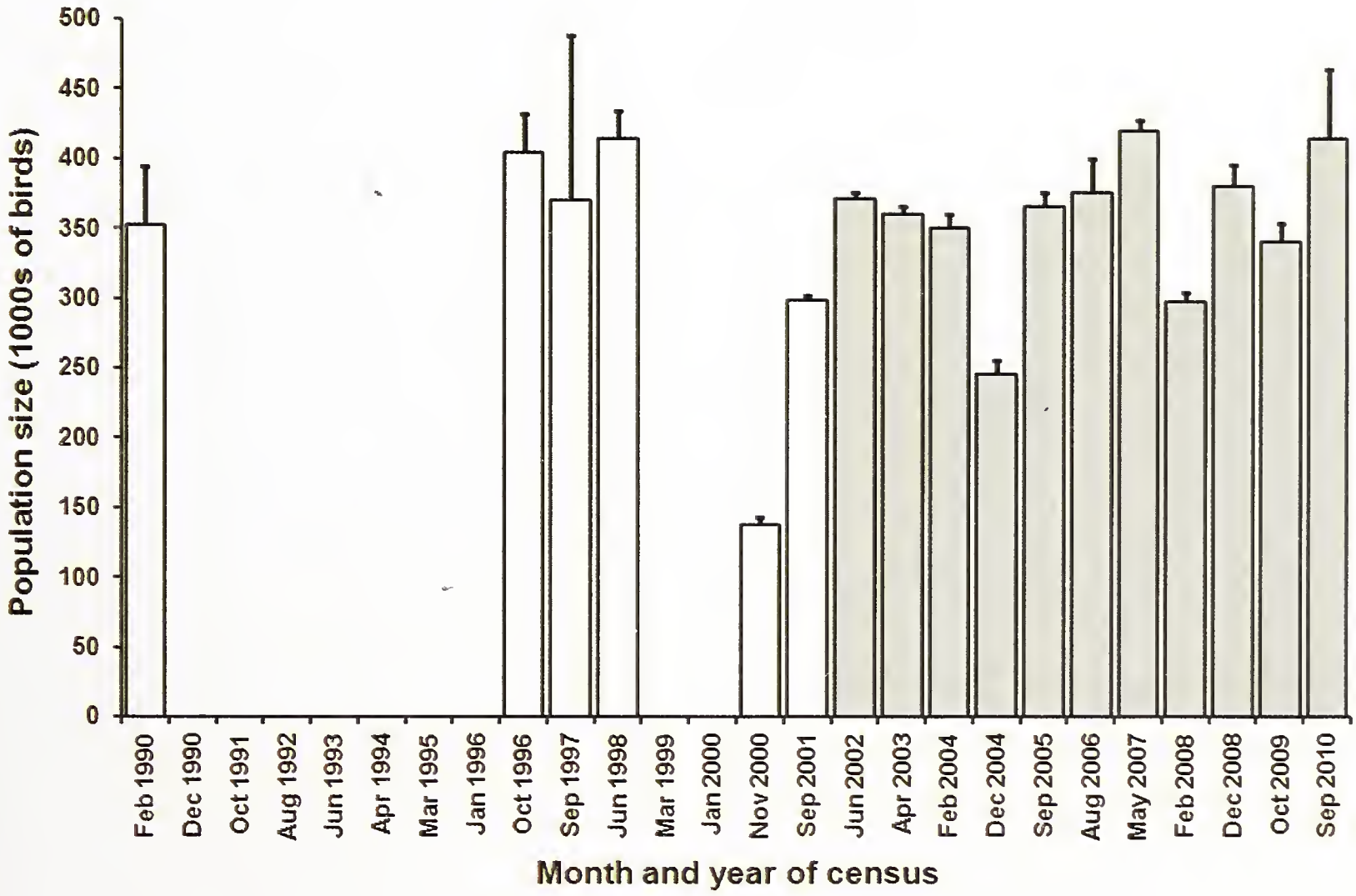

Figure 3. Estimated population size (mean >95% confidence limit) of Sooty Terns *Onychroprion fuscatus* breeding on Ascension Island from 17 censuses undertaken before (open bars) and after (grey bars) the cat-eradication programme. Note that the sub-annual breeding cycle resulted in birds breeding twice in 2004 and 2008. The census in 1997 was completed by N. Ratcliffe (Royal Society for the Protection of Birds).

Population estimée (moyenne avec intervalle de confiance >95%) de Sternes fuligineuses *Onychroprion fuscatus* nichant sur l'île de l'Ascension d'après 17 inventaires organisés avant (barres blanches) et après (barres grises) le programme d'éradication des chats. Noter que le cycle de nidification infra-annuel fait que les oiseaux ont niché deux fois en 2004 et 2008. L'inventaire de 1997 a été exécuté par N. Ratcliffe (Royal Society for the Protection of Birds).

eradication censuses between 2002 and 2007 (i.e. 359,000 ± 51,000 birds (n = 7); Hughes *et al.* 2008) and also greater than the pre-cat eradication status when a baseline survey revealed 368,000 ± 82,000 birds (Ratcliffe *et al.* 1999). However, this apparent increase needs to be placed in context. Large fluctuations in breeding population size are relatively common such as between 2000 and 2001 when the population more than doubled (Hughes *et al.* 2008), but this did not result in a significant increase in the long-term trend (Fig. 3). The large disparity between the May survey (218,000 birds) and the September survey (356,000 birds) in 2010 at Mars Bay clearly indicates that caution is needed when comparing the 2010 census with previous, more comprehensive surveys.

The duration of the 2010 breeding season was 193 days, which is an increase of 30 days (or 18%) on the mean length of previous breeding seasons (n = 13). Of the preceding breeding seasons that were monitored, 2006 had the longest duration at 200 days when 68,000 chicks, sufficient to sustain the population, fledged (BJH unpubl. data). In 2010 large numbers of juveniles in flight during the course of the breeding season were recorded (AIG 2010b).

Previous censuses were scheduled for a period 40–60 days after the first egg was laid (Hughes *et al.* 2008), when the area of the colony was at its maximum (Ashmole 1963). Towards the end of the breeding season unsuccessful breeders usually begin to depart and the colony size reduces (BJH unpubl. data). Surveys in September 2010 were close to the end of the breeding season and may have under-estimated the maximum size of the colony. Why the September 2010 count was higher than the May 2010 count remains to be explained.

The spatial distribution of birds between the two breeding colonies in 2010 was the inverse of previous breeding seasons. Traditionally, two-thirds of the birds nest at Waterside with the remainder at Mars Bay. In May 2010 there were estimated to be 286,600 birds breeding at Mars Bay and in September 127,600 at Waterside. Sooty Terns on Ascension are not site-faithful (BJH unpubl. data) and severe rat predation at Waterside in 2008–09 may have stimulated more Sooty Terns to nest at Mars Bay in 2010.

Although we make the case that long-term population monitoring is key to recording population recoveries in taxa such as seabirds (Mitchell *et al.* 2004), we recognise that the logistics and finances of such exercises, especially on remote islands such as Ascension, can be prohibitive to their success. Although in the breeding seasons prior to 2010 we have managed to overcome such obstacles, it was only through cooperation and data sharing between different agencies that this study was possible. This highlights the need for further cooperation to make such long-term population monitoring a reality and it opens up the possibility perhaps for future reliance on data collected by volunteers (Greenwood 2007). This may be especially attractive in times of austerity when expeditions to remote islands can be prohibited by financial constraints. However, fundamental to the success of volunteer involvement in such data collection is their appropriate level of training (Greenwood 2007). Considerable commitment throughout the breeding season is also required if a reliable estimate of productivity is to be obtained.

Above, we discuss our findings and consider improvements in monitoring efforts on Ascension. Like any predator-eradication programme, our long-term aim is to monitor the Sooty Tern population to detect and monitor its predicted recovery. To date, evidence for an increase in the population size of Sooty Terns from censuses over 13 consecutive seasons is mixed. Three seasons with small breeding populations in 2008 and 2009 were preceded and followed by seasons of relatively large breeding populations. We conclude that further censuses are imperative to characterise the population trend for this species and to detect its predicted recovery since the cat-eradication programme. Allied to this census work is further monitoring of Black Rat *Rattus rattus* populations to detect potential mesopredator release (Courchamp *et al.* 1999) that would have further effects on the progress of recovery because of their adverse impacts on both eggs and chicks (Jones *et al.* 2008). Such rat monitoring work is ongoing and, indeed, will form part of the integrated approach during future AOS field work.

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